FIRRE Remote Sensor Station (RSS)

J.R. Cruickshanks*[a], E.L.Wickstrand[a], T.A. Kramer[a], R.T. Laird[a], C.M. Barngrover[a], C.W.Gardner[b]
[a]Space and Naval Warfare Systems Center, San Diego, 53560 Hull Street, San Diego, CA 92152
[b]SAIC, 4065 Hancock Street, San Diego, CA 92110

ABSTRACT

The Family of Integrated Rapid Response Equipment (FIRRE) is an advanced technology demonstration program intended to develop a family of affordable, scalable, modular, and logistically supportable unmanned systems to meet urgent operational force protection needs and requirements worldwide. The near-term goal is to provide the best available unmanned ground systems to the warfighter in Iraq and Afghanistan. The overarching long-term goal is to develop a fully-integrated, layered force protection system of systems for our forward deployed forces that is networked with the future force C4ISR systems architecture. The intent of the FIRRE program is to reduce manpower requirements, enhance force protection capabilities, and reduce casualties through the use of unmanned systems. FIRRE is sponsored by the Office of the Under Secretary of Defense, Acquisitions, Technology and Logistics (OUSD AT&L), and is managed by the Product Manager, Force Protection Systems (PM-FPS).

The Remote Sensor Station (RSS) provides FIRRE with the ability to remote (or extend the range of) manned/unmanned sensors. The RSS consists of three primary components: (1) an actively cooled and hermetically sealed (NEMA-4X) electronics enclosure, (2) a 22' telescoping tower, (3) and the PM-MEP 531A 2KW GENSET. The current configuration supports a Digital Imaging Infrared (DII) DI-5000 thermal imaging system/visual imaging system (TIS/VIS), a Syracuse Research Corporation (SRC) PPS-5D ground surveillance radar (GSR), an AN/PRS-9 (BAIS) unmanned ground sensor (UGS) receiver, an Intuicom Military Navigator II (MILNAVII) data link radio, and a DTC Communications Palladium 12000 audio/video (A/V) radio. The electronics box is insulated with a radiant barrier and fitted with a EIC Solutions 1500 BTU solid state thermoelectric cooler (TEC) capable of maintaining a safe operating temperature in extreme conditions (<120° Fahrenheit).

1. BACKGROUND

The purpose of FIRRE is to provide the best available force protection technologies to our forward deployed forces today, while assisting the Combat Developer in developing concepts and capabilities analysis for the future. FIRRE provides our forward deployed Soldiers, Airmen, Marines and Sailors with an enhanced layered Force Protection System of Systems capability that provides the means to detect, assess, identify and respond to enemy intrusion activities. FIRRE enhances force protection, keeps friendly forces out of harm's way and allows commanders to return Soldiers to their primary wartime missions.

The proponent for FIRRE is the U.S. Army Maneuver Support Center (MANSCEN) at Fort Leonard Wood, Missouri. Current plans call for FIRRE to participate in a July-August 2006 Comprehensive Force Protection (CFPI) Demonstration at Yuma Proving Ground, Arizona and to eventually integrate with the Counter-Rocket, Artillery and Mortar (C-RAM) program as part of MANSCEN's 360 degree Comprehensive Fixed Site Protection concept. If successful this integrated effort will be deployed in FY2007 providing a Force Protection capability against indirect fire and ground intruders.

The formal requirements for the FIRRE program are being developed by MANSCEN as part of the U.S. Army Training and Doctrine Command's (TRADOC) chartered Unit Protection Concept Capability Plan (UPCCP) Integrated Concept Development Team (ICDT).

* jamesrc@spawar.navy.mil; phone 1-619-767-4273; fax 1-619-553-6188; www.spawar.navy.mil/robots

The FIRRE Integrated Product Team (IPT) was charted by the OSD Joint Robotics Program (JRP) Coordinator and meets periodically as required. The IPT consists of over 60 members from 10 different agencies. Key members include PM-FPS, SPAWAR, MANSCEN, ATEC, PM-RUS, PM-NV and other members of OSD's JRP.

Over a nine month period, the FIRRE IPT developed an "80% solution" that is affordable, supportable, and uses military equipment where possible or readily available commercial equipment where practical. The resulting system has been demonstrated in two week-long field exercises at Hawthorne Army Depot in Nevada over an operational area in excess of 35 square kilometers. Portions of the FIRRE system have undergone formal environmental testing to include heat (to 120° F), blowing rain (to 40 MPH), shock and vibration, transportability, and center of gravity.

2. OVERVIEW

FIRRE has been designed to be deployed in a rapid fashion for tactical missions, or integrated into base operations as part of a complete force protection package. As FIRRE is a system of systems, its configuration is flexible and scalable, and the exact table of equipment for a particular application is based upon METT-T (Mission, Enemy, Troops, Terrain, and Time). Nominal deployment of FIRRE consists of a single command and control (C2) Station controlling multiple unmanned assets operating over an area of approximately 100 square kilometers that approaches the physical extents of the current communications architecture. Shown in figure 1, a typical FIRRE system for performing perimeter security of a moderate-sized (7 x 5 kilometer) ammunition base could consists of:

- 1 M1152 HMMWV
- 1 S-788 TYPE I Shelter housing C2 Station Equipment
- 6 Blue Sky Masts with Radio Antennas
- 1 PU798 10KW Generator Trailer
- 2 M1102 Support Equipment Trailers
- 4 Remote Sensor Stations
- 50 BAIS Unattended Ground Sensors
- 2 FIRRE Unmanned Ground Vehicles

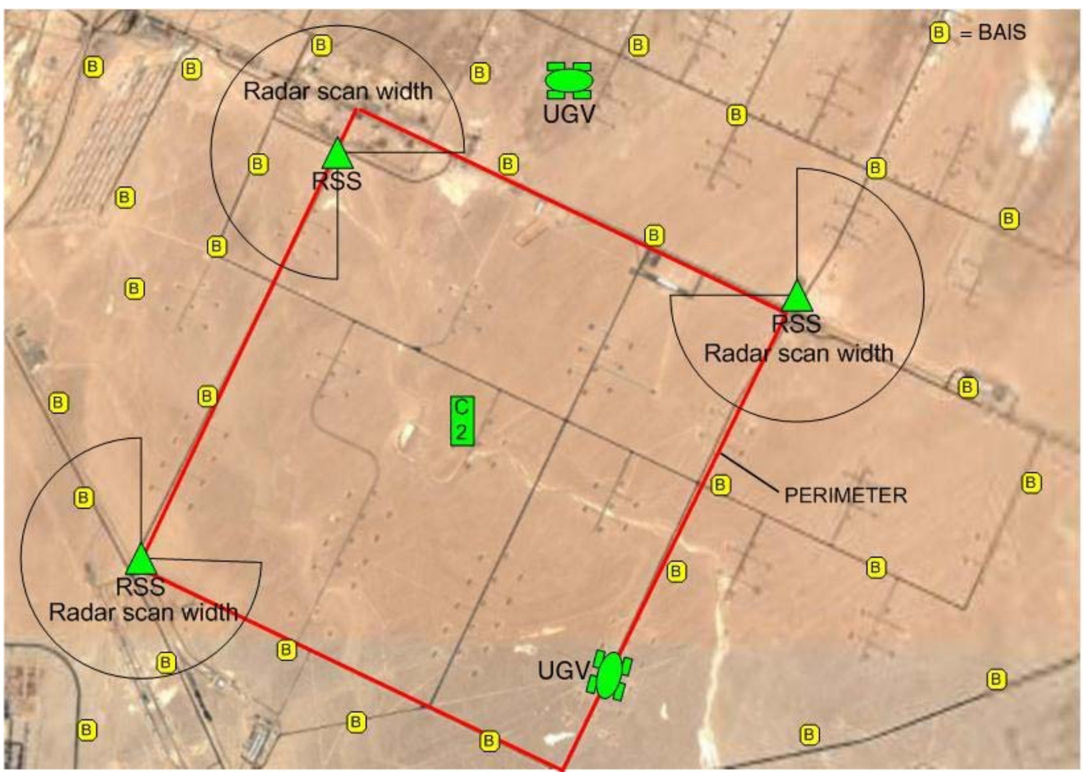

Figure 1: Conceptual deployment of the FIRRE system.

3. REMOTE SENSOR STATION (RSS)

As the name suggests, the purpose of the RSS is to *remote sensors*. Shown in Figure 2, the RSS provides a configurable, extensible platform to remote nearly any sensor. Each RSS is comprised of four major subsystems: sensors, tower, electronics, and power. Two complete RSS systems and support equipment can be transported via an extended light tactical trailer (LTT). Emplacement of the RSS requires 4-6 persons and 2-4 hours depending on training, weather, and soil conditions.

Currently, the RSS supports a ground surveillance radar (GSR), unattended ground sensors (UGS), and a thermal imaging system/visual imaging system (TIS/VIS) sensor. It is deployed at the perimeter of the area of interest (AOI) to provide remote sensing to the extents of the equipment's capabilities. The RSS consists of: 22 foot collapsible tower, guy wire kit, *MEP-531A* 2KW portable diesel generator (type classified), *AN/PPS-5D* GSR, *DII DI-5000* TIS/VIS, C2 data radio antenna, audio/video downlink radio antenna, GPS antenna, *AN/PRS-9* antenna, electronics box, camouflage netting, and interconnect cables.

The *MEP-531A* generator supplies power to the RSS electronics box (E-Box) and can support over 24 hours of operation with one 20 liter can of diesel fuel.

The RSS E-Box is a thermoelectrically cooled transit case that houses the sensor control and interface equipment. It is insulated to maintain a safe operating temperature in extreme conditions (up to 120° F). The enclosure contains: thermoelectric cooler, temperature sensors, power conditioning unit, DC power supply, *AN/PRS-9* receiver, C2 data radio, audio/video downlink radio, and embedded computer.

The GSR, UGS, and TIS/VIS are interfaced to the embedded computer in the RSS E-Box. The data from the sensors is processed and sent back to the C2 Station, where it is displayed within Joint Battlespace Command and Control Systems for Manned and Unmanned Assets (JBC2S). Remote controls are provided through JBC2S for each sensor. Sensor data processing will increase in complexity over time as the system is tested; the utility of the system will increase as the sophistication of the data processing improves (crawl first, walk later). The user will decide what is useful and FIRRE will adapt as possible (within resource limitations).

Figure 2: RSS at Integration Assessment - HWAD.

3.1 Tower

The tower provides an elevated platform to attach sensors and communications equipment. The height requirement for the sensor platform was generated by simulating sensor performance through the use of Mission Planning Rehearsal (MPR) software. It was determined that the GSR was most effective at an elevation greater than 20 feet. At this height, the sensor platform aids in obtaining line-of-site communications and provides a superb vantage point for visual sensors.

The RSS tower was manufactured by Aluma Tower (consisting of three telescoping sections) that when fully extended, measures 22 feet. Weighing only 180lbs, the tower can easily be unloaded from the LTT by 4 persons. The tower is staked at the base using five rebar stakes approximately 3 feet each. Before the tower is fully extended duckbill anchors (Figure 3) are driven into the ground and set, and provide an attachment point for the guy cables. There are a total of 12 guy cables, four for each edge of the triangular structure. The bottom and middle sections of the tower are guyed by three cables each. The top section is fitted with an anti-torsion assembly that uses the remaining six guy cables to prevent any twisting of the tower.

At the top of the tower is the sensor platform (Figure 4). The platform is designed to accommodate the fixed sensors in addition to the four antennas. A red strobe light has been emplaced and can be remotely enabled or disabled as needed.

The tower (as with all other sensors and hardware) is painted desert-tan to match the target environment. Around the base of the tower to the top of the first section camouflage netting is draped to further decrease its visibility by blending it into surrounding brush (Figure 2).

Figure 3: Anchors.

3.2 Sensors

The RSS currently supports three major sensor systems: Thermal Imaging System/Visual Imaging System (TIS/VIS), Ground Surveillance Radar (GSR), Unattended Ground Sensor (UGS) receiver.

3.2.1 GPS

A GPS antenna is mounted on the tower and routed to the EBOX where the *Intuicom Military Navigation II (MilNav II)* radio uses the signal to compute the tower's grid coordinates. The data is fed back to the C2 Station and used to position the RSS within JBC2S.

Figure 4: Sensor platform and anti-torsion assembly with guy cables.

3.2.2 TIS/VIS

A *DII DI-5000* TIS/VIS is mounted four feet above the sensor platform and is used for surveillance and classification purposes. The *DI-5000* is an integrated pan and tilt thermal imager combining CCD and thermal technologies. The thermal imager provides the ability to see in total darkness and in adverse weather conditions such as rain, snow, and fog. Designed for perimeter security and surveillance, the DI-5000 can hold up to 99 preset positions for perimeter scanning. Slip rings allow the camera to continuously pan in either direction, providing 360 degree coverage. The camera also has the ability to overlay the imaging from the thermal imager over the visual imager, allowing the user to find a balance between the two systems that will provide the user with the most informative picture possible given the conditions and situation. The range of the DI-5000 is determined by the combination of imagers and lenses. The configuration used by FIRRE consists of a 25 micron detector and 100mm lens. Based on the Johnson Criteria the camera is capable of detection at 2000m, recognition at 1,200m, and identification at 900m.

3.2.3 GSR

The *AN/PPS-5D* is a man-portable GSR developed by Syracuse Research Corporation (SRC). It is used to detect and audio classify personnel, and wheeled and tracked vehicles outside the AOI perimeter. It is capable of detecting personnel up to 10km and vehicles up to 20km. Detections from the GSR are sent to the operator at the C2 Station.

3.2.4 UGS/BAIS

The *L3 Communications AN/PRS-9 Battlefield Anti-Intrusion System (BAIS)* is used to provide coverage of areas outside of the AOI perimeter that cannot be covered by the other sensors (GSR and TIS/VIS), and is the U.S. Army's type standard unattended physical security and force protection system. The BAIS provides early warning, intrusion detection, and threat classification of personnel and vehicles. Seismic/Acoustic Sensors (SAS) can be supplemented with infrared, long-range infrared, and magnetic sensors to provide additional information such as target count and target direction. The BAIS currently consists of ten unmanned ground sensors (UGSs) per RSS, but is capable of supporting several hundred. When an SAS is triggered it transmits the classification (if any) of the intruder to the RSS, which is then relayed to the operator at the C2 Station.

Each RSS includes an *AN/PRS-9* receiver. BAIS sensor fields are placed around the AOI perimeter as dictated by the MPR software. The individual BAIS sensors (seismic/acoustic) communicate to a BAIS receiver that is located within the E-Box of an RSS (nearest the sensor field). The BAIS sensors report to back to the RSS, which then passes the data to the C2 Station where it is displayed in JBC2S. The BAIS sensor data can be sent a much longer distances using this approach. The BAIS sensors are used to queue the dispatch of the unmanned ground vehicle (UGV) to an area of alarm. When a BAIS sensor is triggered, the system will alert the operator and ask for permission to send a UGV to investigate.

Figure 7: Battlefield Anti-Intrusion System (BAIS).

3.3 E-Box

All RSS sensors and communications equipment are controlled and powered through the E-Box. The RSS electronics equipment is protected from the environment and shock and vibration by the E-Box, which is a modified transit case (Figure 5). The transit case is an *EIC Composites 7513* made from a polymer-fiberglass composite which houses an elastomeric shock mounted 19” rack with 13U of space for equipment and is environmentally sealed (rated NEMA4X). The COTS case sufficiently protects the equipment from shock and vibration, but is not capable of dissipating internally generated heat, reflecting radiant energy and insulating from high ambient temperatures, or connecting to internal components without affecting its environmental integrity.

3.3.1 Insulation

A two-layer insulation system is used to combat the high ambient temperatures found in desert environments. The system uses a more traditional layer that contains pockets of air with a newer, high-tech solution called radiant barrier insulation. Radiant barrier insulation reflects heat in the form of radiation; however, to do so effectively, there must be a minimum of 3/4 inch of air between the radiant barrier and the surface of the transit case in order to reduce the transfer of heat through conduction. To accomplish this, a honeycomb structure is sandwiched between the walls of the transit case and the radiant barrier insulation. The honeycomb creates small pockets of air that contribute in reducing heat flow and provided three-quarter inch separation from the walls of the transit case and the radiant barrier insulation, while reducing the surface area in contact with it. The honeycomb has a cell size of one-half inch and is constructed of impregnated Kraft paper making it highly resistive to heat flow.

3.3.2 Thermoelectric Cooler (TEC)

Actively removing the heat generated by electronic components located inside of the E-Box is necessary in order to keep the internal temperature under the maximum operating temperature. Maximum operating temperature is determined by the component housed in the E-Box with the lowest operating temperature. Passive transfer of the heat (conduction through the walls of the enclosure) is not practical since ambient temperatures will be greater than the maximum allowed internal temperature. Also, the enclosures radiant barrier insulation will keep a large part of the heat inside. An environmental control unit (ECU) is necessary. In order to maintain the environmental integrity of the E-Box, an ECU that does not exchange air is required.

A TEC was chosen for the ECU for two reasons: TECs do not exchange air but are heat exchangers and they have minimal moving parts reducing the probability of failure. However, there are also several disadvantages of using a TEC: they are inefficient and are large and heavy compared to alternatives. These issues were addressed in the mechanical and electrical design of the E-Box.

The RSS uses the *EIC Solutions, Inc. 1500 BTU TEC* which weighs 50lbs. and requires 120VAC and 7.3A at peak operation.

Figure 5: RSS E-Box.

3.3.3 Egress Panels

The egress panels provide an area to mount MILSPEC connectors giving access to the internal components without risking the environmental integrity of the enclosure. The major design feature of the egress panels is that they are removable allowing for the addition of new connectivity without much redesign or fabrication. Rubber gaskets and generous use of fasteners about the perimeter of the panel ensure that the enclosure's NEMA 4X rating is maintained.

3.3.4 CPU

Sensor input is processed by the CPU. Data is collected via serial port or DIO board, processed, and when appropriate, the information is packaged and sent to the C2 Station. The motherboard is an *Ampro Little Board 700* configured with an *Intel 933MHz Pentium III* processor and 512MB of PC133 DRAM. The board is of a PC/104+ form factor and supports a PC/104 stack. A PC/104 stack DIO board processes all analog and digital inputs. It is also used to control several indicators on the main egress panel and a strobe light on the tower.

3.3.4.1 Embedded XP

The embedded PC uses the Windows XP Embedded operating system off of a 1GB *SanDisk Extreme III* compact flash (CF) drive. Windows XP Embedded was chosen for two primary reasons: leverage existing code and for its highly scalable and modular characteristics.

Windows XP Embedded is a componentized version of the popular Windows XP operating environment. Using the Microsoft's Windows Embedded Studio only required components were included in the image, which is under 240MB. One such component is the Enhanced Write Filter (EWF). EWF provides protection against destroying flash media through excessive read/write cycles. During normal operation a RAM overlay is used rather than the CF. This feature also prevents rogue software and viruses from permanently damaging the image. Since no data is persistent simply power cycling the PC will revert to the original image.

3.3.4.2 Resource Interface Modules (RIM)
The software modules that control the RSS are called Resource Interface Modules (RIMs). Figure 6 shows the hierarchy of the different RIM components and how these pieces of software interact with each other and with the hardware.

3.3.4.3 RSS RIM
The RSS Resource Interface Module (RIM) is the core application that controls communication between each module, while monitoring the status of the Electronics Box. This software monitors the internal temperature in key locations within the box to verify that the system does not overheat and fail. When the internal temperature increases above specific levels, the system reacts in two ways. A message is sent to alert the user in the C2 Station and LEDs on the E-Box are illuminated to show the current hazard level of the internal temperature. The RSS RIM facilitates communications between the C2 Station and the sensor modules, including *AN/PRS-9*, *DI-5000*, and *AN/PPS-5*.

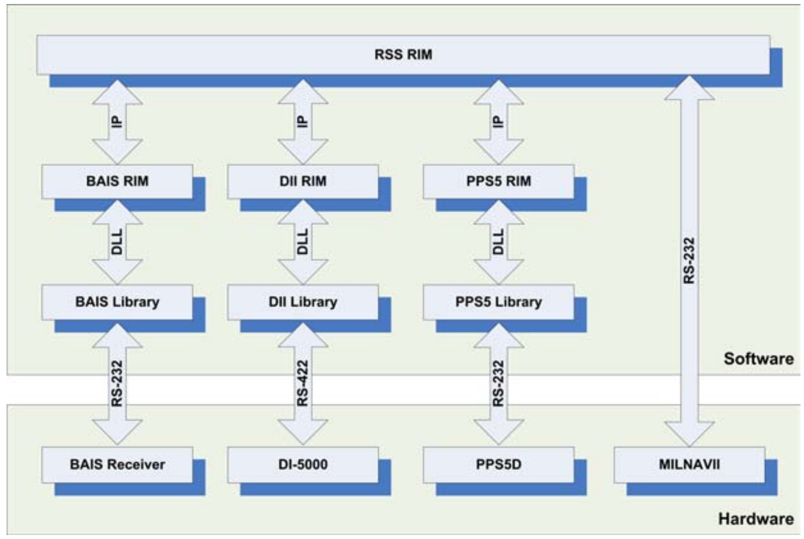

Figure 6: RSS RIM software/hardware hierarchy.

3.3.4.4 BAIS RIM
The BAIS RIM software controls the configuration and communication with the BAIS sensors. A network of up to 63 BAIS sensors can be monitored using a single receiver that interfaces to the embedded PC using an RS-232 interface. When a detection message is received by the BAIS RIM, this information is passed back to the RSS RIM which in turn, passes it back to the C2 Station.

3.3.4.5 DI-5000 RIM
The *DI-5000* RIM handles messages sent from the C2 Station to control the operation of the *DI-5000* camera: zoom in and out, pan and tilt, and fade between TIS and VIS. Also, this module sends updates to the C2 Station regarding the pose of the camera. The RIM does not handle any video data; this is handled by a dedicated *DTC Communications* radio link.

3.3.4.6 AN/PPS-5 RIM
The *AN/PPS-5* RIM handles messages sent from the C2 Station to control the *AN/PPS-5* radar. The module can put the radar into scan mode or the C2 Station operator can control the radar directly. The RIM also has the ability to calibrate upon start-up and to recalibrate if necessary. The *AN/PPS-5* does not have an absolute encoder, so upon power up, the current heading given by the positioner becomes the zero for the radar. The addition of a proximity sensor mounted on the tower is used to align the GSR with the tower. All data retrieved by the radar is handled by this RIM and forwarded to the C2 Station. In addition, the RIM sends status updates to the C2 Station that includes azimuth, scan width, and other important fields.

3.3.4.7 Multiple Resource Host Architecture (MRHA)
All communication between the Resource Interface Modules (RIMs) and the C2 Station use the Multiple Resource Host Architecture (MRHA) IDD protocol. The MRHA messages sent out by the C2 station are only received by the RSS RIM, which then forwards the message to the appropriate sub module. The three sub modules handle any incoming MRHA message and have the ability to send out MRHA messages through the RSS RIM to the C2 Station.

The MRHA was developed by SPAWAR Systems Center, San Diego as the command and control system for the U.S. Army's Mobile Detection Assessment Response System (MDARS) program. MDARS is fixed site force protection system that consists of multiple semi-autonomous UGVs performing automated patrols, as well as intrusion sensors and active barriers.

3.4 Power

The E-Box is powered using a standard 110VAC 20A wall outlet if available, or by the *PM-MEP 531A* 2kW tactical diesel generator (Figure 8). The generator outputs 120VAC at 60Hz (adjustable). Power from the generator is conditioned by a *Tripp-Lite LCR2400* rack-mounted line conditioner (LCR) housed within the E-Box. The LCR prevents voltage spikes and brownouts from damaging the systems sensitive electronics. The clean power is used to supply an AC/DC power conversion unit (PCU). The PCU provides isolated DC outputs used to power all sensors, radios, and other electronics. Figure 9 shows the RSS E-Box power flow chart.

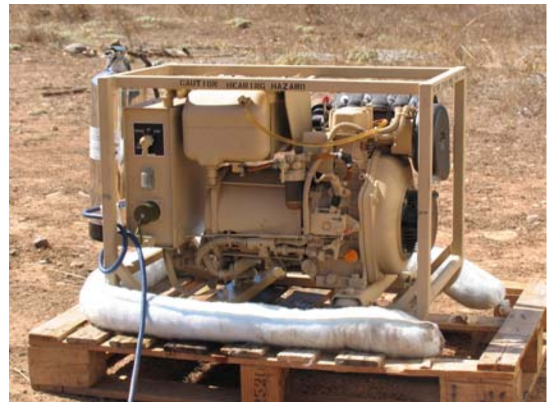

Figure 8: PM-MEP 531a 2kW tactical generator.

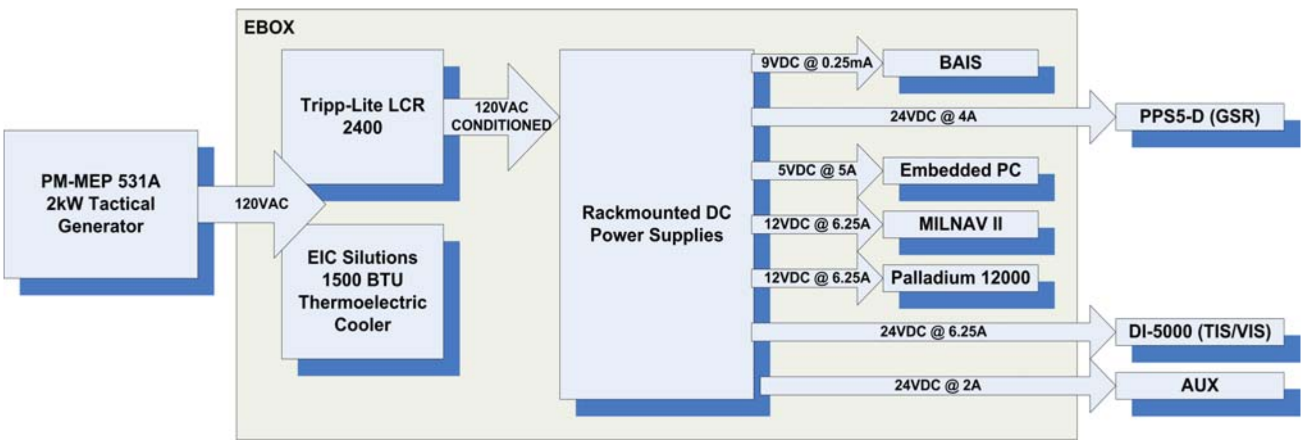

Figure 9: RSS E-Box power distribution and conversion diagram.

3.5 Communications

3.5.1 Radios

The requirements of FIRRE's mission dictates the use of high power, long range communications equipment rather than standard 802.11 wireless networks normally used for robotic applications. Typically, when a TCP/IP network is used, both command and control and video signals are sent over the same link; however, there are currently very few TCP/IP radios capable of communicating in a mobile environment with bandwidth sufficient for high quality video and over five kilometers range. The few radios that do exist, such as the *AN/VRC-99*, are prohibitively expensive and most have embedded COMSEC encryption that makes them problematic for unmanned systems. FIRRE uses two separate radio links that provide the necessary performance while staying within budget.

Intuicom Military Navigator II (MilNavII) UHF transceivers are used for bi-directional command and control with a maximum throughput of 128kbps (full-duplex), 4W output, and a stated 60+ mile range (LOS). The *MilNavII* can be configured in point-to-point, point-to-multipoint, and repeater modes and also has a built-in WAAS capable GPS. The *MilNavII* radio provides three virtual RS-232 serial channels between two radios in point-to-point mode. The first channel is used for bi-directional command and control using a derivative of the MRHA protocol. The second channel provides one-way differential GPS correction messages from the FIRRE C2 Station to the UGV. The third channel can be used as a remote terminal into the FIRRE UGV to allow for remote debugging.

DTC Palladium COFDM transmitters and receivers are used to send a single channel of high quality NTSC video to the C2 Station. To achieve the desired range, a 12W external amplifier was added, and for non-mobile applications, a 25° 15 dB directional antenna is also employed. The receiver uses two omni-directional antennas in a spatial diversity configuration.

Both of these radio links are used in point-to-point mode. The current limit based on rack space in the C2 Station is 6 resources (any combination of FIRRE UGVs or RSS towers).

3.5.2 C2 Station

The C2 Station is a self-sustaining mobile command post for operating multiple remote unmanned assets (sensors, vehicles, systems). The C2 Station is housed in an *S-788 TYPE I* shelter that rides on an *M1152 HMMWV* (see Figure 10). The *M1113 HMMWV* is an acceptable substitute for the *M1152 HMMWV* in terms of its weight carrying capacity.

Figure 10: C2 Station.

The C2 Station supports two operators and hosts the JBC2S [1], which is the application software developed by SPAWAR Systems Center San Diego that provides control and situational awareness of all FIRRE unmanned systems. The C2 Station also hosts the Mission Planning and Rehearsal (MPR) software used by commanding officers to select and place sensors to provide coverage for a particular facility. Additional application software, including the *ESRI ArcGlobe* terrain visualization software and the *IndigoVision Command Center* network video recording, software are hosted in the C2 Station [2].

3.6 Transportation

Transporting the RSS towers and support equipment is accomplished using an extended (modified) *M1102 Light Tactical Trailer (LTT)*. The Phase II trailer has an extended bed (120" vice 86"); the base trailer is type classified. The modifications include mounting brackets to accommodate towers, and D-rings used to secure equipment with ratchet straps. The trailer can be towed by any standard HMWWV and supports two complete RSS systems. When in theatre, a HMMWV will be made available by the deploying unit to tow the LTT.

Figure 11: LTT loaded with one RSS.

Equipment for one complete RSS includes: RSS tower, GSR, UGS, TIS/VIS, *MEP-531A* portable diesel generator, E-Box, hardware mounts, antennas, interconnect cables, five one-gallon diesel fuel cans, and camouflage netting. One complete RSS tower system is stored and shipped in five *Pelican* cases and two military stuff sacks. The GSR, UGS, TIS/VIS, antennas, hardware, and interconnect cables are each stored in a labeled *Pelican* case and secured to the trailer bed. Each case has custom foam cutouts to protect the equipment from shock and vibration during transit. The cases themselves are rugged and water tight. The camouflage netting and guy cable kits are stored in military stuff sacks and secured to the trailer. The *MEP-531AI* 2kW generators, fuel cans, and E-Boxes are strapped directly to the trailer. The towers are secured to the custom mounting brackets. Figure 11 shows the LTT with equipment for one complete RSS system.

A trailer load configuration was determined and analyzed for center of gravity and overall weight in Solid Works. The system has survived shipment across the country in this configuration. The trailer configuration was also tested for shock/vibration, center of gravity, tilt, and transportability at Aberdeen Test Center (ATC). The system was verified for safety and functionality during and after each test.

3.7 Environmental Testing

The RSS system was subjected to heat, wind, and rain testing at ATC in Maryland. ATC is a major range and test facility base operating under the department of defense directive 3200.11 with the primary mission to support DoD test and evaluation requirements (www.atc.army.mil).

3.7.1 Heat Test

In a controlled temperature heat chamber the C2 Station and RSS were subjected to three consecutive 24 hour heat cycles with maximum solar load and an ambient temperature of 120°F. Operational checks were performed frequently to verify the functionality of the following: communication with the E-Box, audio from the E-Box, TIS/VIS pan/tilt and video, and *AN/PPS-5* radar scan.

The C2 Station and RSS maintained functionality throughout the 72 hour heat test with the exception of one minor failure; the *DI-5000* pan and tilt capabilities were lost during the first cycle. Video was lost during the first maximum solar load and capabilities did not return as the temperature decreased. The suspected cause was an undervoltage condition due to increased amperage draw. The manufacture has supplied us with an upgraded model with higher input voltage capabilities. This, in conjunction with a larger power supply located in the E-Box, has eliminated camera failures in high temperature/high solar load conditions.

The RSS E-Box internal temperature was monitored continuously and maintained a 20^{o}F differential from ambient temperature in the heat chamber. All electronics in the E-Box functioned effectively throughout the 72 hour heat test.

3.7.2 Wind and Rain Test

One fully erected RSS tower including all sensors and E-Box were subjected to controlled 40 mile per hour wind and rain. The tower showed minimal to no movement in the wind; however, the radar was unable to scan accurately. The E-Box proved to be water tight and the rain caused no failures to the RSS.

4. FUTURE PLANS

The RSS was developed as a prototype. Many of the components were chosen for their availability, cost, and ease of integration in addition to their specifications. There are several systems that should be further developed, redesigned, or altered in order to make the RSS a more effective, reliable, maintainable, tactical, and deployable system.

4.1 Tower

Primary objectives in the next phase of spiral development for the tower would include configurability and the reduction of tools needed to erect the tower. By creating a modular sensor platform, the cost and time required to integrate an additional sensor or payload would be greatly reduced. Reducing the need for tools in the setup of the tower would increase the speed in which the system could be deployed, making it more valuable in tactical situations.

4.2 Sensors and Payloads

A non-lethal payload utilizing the Long Range Acoustic Device (LRAD) is being developed for the FIRRE UGV to provide a limited response capability. This capability can be adapted and used on the RSS. Coupled with a long-range directional microphone the user would be able to have a conversation with someone as far away as 1 kilometer. In the next spiral of development for FIRRE, other payloads will be considered for integration such as wide area infrared sensors, unattended lethal/non-lethal weapon systems such as the Common Remotely Operated Weapons System (CROWS), MATRIX, and the Networked Remotely Operated Weapons System (NROWS).

4.3 E-Box

Objectives for the second iteration of the E-Box include reduction in size and weight. This can be accomplished by building a more efficient and tightly integrated power distribution and conversion system, and using components with higher operating temperatures. Smaller components that run at higher temperatures will allow for the reduction in size of the enclosure and use of a smaller TEC, greatly reducing overall size and weight of the E-Box while increasing its capabilities.

REFERENCES

1. T.A. Kramer, C.M. Barngrover, R.T. Laird, J.R. Cruickshanks, M. Dinh, G. A. Gilbreath *FIRRE Joint Battlespace Command and Control System for Manned and Unmanned Assets (JBC2S)*, SPIE Proc. 6230-82, Orlando, FL, 2006.
2. R.T. Laird, T.A. Kramer, J.R. Cruickshanks, K.M. Curd, K.M. Thomas, J.C. Moneyhun, *FIRRE Command and Control Station (C2)*, SPIE Proc. 6230-85, Orlando, FL, 2006.